**Figure 1 Cloud *NINE!***

FCC IWG-***NINE!***
WRC-99

# Meeting Notice and Draft Agenda

The second meeting of FCC's informal working group ***NINE!*** on Regulatory/Procedural Matters will convene at 9:30 a.m., Thursday, April 2nd in Room 847, 2000 M Street, NW, Washington, DC.

The draft agenda:

1. Approval of agenda
2. Introductions
3. Draft minutes, March meeting
4. GBMT earth stations
5. TG 1/6 Document 11
6. Other business

Mark your calendars. Subsequent meetings of ***NINE!*** are:

| | | | | |
|---|---|---|---|---|
| 5/7 | 6/4 | 7/2 | 8/6 | 9/3 |
| 10/1 | 11/5 | 12/3 | 1/7/99 | 2/4/99 |

at 9:30 a.m., above room.

The GBMT earth stations document that you are reading was distributed and edited at the April meeting. This will not resemble the paper document that was distributed.

**USA/ /1**
**ADD**

Notwithstanding any other provision of the Radio Regulations, an earth station on board a ~~ship~~vessel may communicate with a space station in the fixed-satellite service transmitting in the band 3 700 - 4 200 MHz and receiving in the band 5 925 – 6 425 MHz. Each such ~~ship~~vesselborne earth station will be established and operated at least [ ] kilometers beyond land so as to not cause harmful interference to all satellite networks and terrestrial assignments notified in those bands ~~3 700 - 4 200 MHz~~ and appearing in the Master Register with a favorable finding ~~as of [date of provisional application of Final Acts]~~. ~~If any new or modified space or terrestrial assignment in the band 3 700 - 4 200 MHz and situated within the Appendix S7 coordination contour of such an earth station on board a ship is to be brought into use on or after [date of provisional application of Final Acts], coordination should be effected with the administration authorizing the earth station on board a ship.~~

**Reasons:** To enhance shared use of the spectrum and orbit resources.

INTERNATIONAL TELECOMMUNICATION UNION

**RADIOCOMMUNICATION STUDY GROUPS**

**Document 1-6/11-E**
**10 March 1998**
**Original: English only**

Source: Document 4-9S/TEMP/39

**Working Party 4-9S**

DRAFT NEW REPORT [DOC. 4-9S/TEMP/39]*

# OPERATION OF EARTH STATIONS ON BOARD VESSELS IN THE FIXED-SATELLITE SERVICE IN THE BANDS 3 700-4 200 MHz AND 5 925-6 425 MHz AND COORDINATION WITH OTHER SERVICES ALLOCATED TO THESE BANDS

(Questions ITU-R [Doc. 4-9S/TEMP/21]/4 and [Doc. 4-9S/TEMP/23]/9)

## I. INTRODUCTION

Although there are existing services that provide narrowband satellite communications in certain locations at sea (*e.g.*, MMSS), there is a need for global broadband maritime telecommunications ("GBMT") services for reliable transmission of high-speed data, voice, and video applications on vessels. At present, GBMT earth stations are in operation in all ITU Regions on a variety of sea-going vessels, vessels and mobile platforms, utilizing existing fixed-satellite service space segment in the bands ranges 3 700-4 200 MHz and 5 925-6 425 MHz on an experimental basis. The broadband signal capacity, ubiquitous coverage, dependable operation, resistance to weather-related interruptions and ready availability afforded by existing fixed-satellite service networks in the 3 700-4 200 MHz and 5 925-6 425 MHz bands make them desirable for GBMT operations.

This contribution provides a general description of existing GBMT operations in the 3 700-4 200 MHz and 5 925-6 425 MHz in the fixed-satellite service on board vessels, describes a methodology that may be used to assess the potential for interference into fixed service receivers from GBMT earth stations, as well as the potential for interference into GBMT receivers from fixed service transmitters.

## II. DESCRIPTION OF DEPLOYED GBMT SYSTEMS AND THEIR OPERATIONS

### A. Description of GBMT Systems

GBMT operations utilizing 3 700-4 200 MHz and 5 925-6 425 MHz fixed-satellite service frequencies are now employed in all ITU Regions on a variety of large vessels such as passenger ships, seismic research and petroleum exploration ships, and naval vessels. (The size, weight and expense associated with GBMT installations in the 3 700-4 200 MHz and 5 925-6 425 MHz band dictate that only the largest vessels are candidates for such facilities.) In addition, movable oil and gas drilling platforms employ GBMT for exchange of high-speed data essential to their operations. A

* This Draft New Report should be brought to the attention of ITU-R Task Group 1/6.

GBMT earth station utilizes an extremely reliable stabilized platform and proven VSAT technology. Each GBMT installation on board a ship or other vessel is individually tied to a central control center. The GBMT system comprises three basic elements: (1) the antenna subsystem, (2) the RF subsystem, and (3) the digital/modem subsystem.

The following system description is provided as an example of a typical GBMT system used on vessels in ports and territorial waters. System characteristics as used in this study are found in [Document 4A/40-E].

## 1 Antenna Subsystem

The antenna subsystem consists of a stabilized platform and antenna. These components are mounted above decks and are covered by a rigid radome composed of composite foam/fiberglass. In an illustrative system, the antenna is a steerable 2.4 meter aluminium axis-symmetrical parabola with either a circular or a linear polarized prime focus feed. The antenna horizon gain ranges from 0 to -10 dBi. The G/T is 16.5 dB/K or greater. The antenna centerline is a fixed value, such as 24 meters above mean sea level. The antenna operating characteristics meet all ITU and INTELSAT specifications as set by ITU-R S.524-5, S.580-5, S.731, S.732 and IESS 601.

The stabilized platform uses a microprocessor-based antenna control unit. It stabilizes the earth station on a mobile seaborne platform to maintain signal lock and maintains a pointing accuracy to within +/- 0.1 degree. The unit adjusts for the relative position of the mobile platform and the movements caused by wind and waves. The system is set up to terminate transmissions instantaneously in the event signal lock is lost.

## 2 RF Subsystem

The RF subsystem consists of standard transmitters and receivers, and conventional up- and down-converters certified for performance with satellites. These are mounted above decks with the antenna in the rigid radome. Transmitter power density at the antenna input is fairly low, in the -7 to -11 dB(W/4kHz) range.[1] Use of higher power transmitting density is currently under study.

## 3 Digital/Modem Subsystem

The digital/modem subsystem, which is located below decks in the radio room, consists of an antenna control unit, and other conventional, readily-available electronic equipment designed to work in accordance with the above-specified operational parameters.

[1] The power density in units of dBW/4kHz = $P_t + 36 - 10 \log_{10} B + PF$. For example, with a 100 Watt transmitter, power density equals -7dBW/4kHz. *See* CCIR Report No. 792, "Calculation of the Maximum Power Density Averaged Over 4 kHz of an Angle-Modulated Carrier" (1986).

## B. GBMT System Operations

### 1 In General: Three Distinct Operational Phases

For studying the interference potential between GBMT systems and the fixed service, three distinct phases of operation need to be considered: (i) operations in open sea;[2] (ii) operations while at a specific, fixed location, such as when a ship is docked in port; and (iii) operations in-motion in the sea lanes and port channels near shore when a ship approaches or departs a port. Only the last two of these operational phases are considered. When a ship or vessel employing GBMT is a sufficient distance offshore, its operations will not affect (or be affected by) terrestrial fixed services or fixed-satellite service facilities.

When the ship or vessel is docked in port, or is otherwise in a stationary mode (such as anchored in the fixed location of a petroleum drilling platform), it is in a specifically identifiable location.

When a GBMT-equipped ship or vessel approaches shore (as when moving in or out of port, resembling in some respects a mobile earth station), it requires a different type of analysis to determine the interference potential to and from fixed service stations than when it is docked in port. The following section proposes a "critical contour point" methodology for determination of the interference potential in this phase of operation.

### a. GBMT Operations in Open Sea

When vessels employing GBMT operate in open sea, they should be sufficiently far from terrestrial fixed service and fixed-satellite service stations that they do not represent a source of potential interference to those stations, nor do they suffer interference from terrestrial 4 GHz transmitters. While this distance may depend on terrain blockage, propagation conditions, and other circumstances including frequency use on off-shore platforms, it would be desirable and practical from an operation perspective to select a fixed distance from shore where it may be safely presumed that GBMT stations may operate without the need to coordinate with terrestrial fixed and fixed-satellite service stations. One administration has proposed a distance of 100 km for this purpose.

While in open sea, beyond the required distance for coordination with terrestrial stations, GBMT-equipped vessels need only be concerned with interference to and from other vessels at sea that may be employing systems in the same frequency bands.

### b. GBMT Operations in Stationary Mode

Vessels equipped with GBMT facilities that are stationary in port can be coordinated, assuming that appropriate regulatory status is agreed at a future allocations conference, employing applicable procedures and technical parameters set forth in Recommendations ITU-R IS.847 (coordination area) and SF.1006 (interference potential). GBMT-equipped vessels are inevitably large, with all of their operations confined as a matter of necessity to specified port channels (the path into and out of a port, generally surrounded by land), sea lanes (the limits marked just outside a port beyond the port channels indicating where a ship may safely operate while approaching or departing a port), and piers. For purposes of coordination, the entire area of the identified pier in which a GBMT-equipped ship is located can be specified with precision, analysed and coordinated for interference.

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[2] For convenience, the term "in open sea" as used herein denotes GBMT operations at a sufficient distance from the nearest shore points such that potential interference to or from terrestrial stations is no longer a concern.

The GBMT-equipped vessels usually dock at the same piers on every trip, so it is possible to coordinate operations at the pertinent piers using existing coordination procedures. GBMT-equipped drilling platforms can be coordinated in the same manner.

### c. GBMT In-Motion Operations Near Shore

While GBMT-equipped vessels are within 100 km from the nearest shore point, they are "under way" in the channel or within the sea lane limits, and are constantly in motion, travelling at speeds ranging from 4.3 to 13 knots (approximately 8 to 24 kilometres per hour). The large vessels which employ GBMT require identified piers, defined port channels, and specified sea lanes. These port channels and sea lanes are clearly physically demarcated in every case so that they may be observed and followed by large vessels, and they are also set forth on maps and charts.[3] Large vessels typically spend some time docked at identified piers, and periodically go to sea.[4] Multiple vessels that are equipped with earth stations may operate at the same port, but each ship of a given type operates with the same parameters as others of its type, including pier locations and limits of the path travelled in and out of the port (*i.e.*, the port channel and limits of the sea lanes).[5] These in-motion GBMT operations near shore present a potential for interference to terrestrial fixed station receivers in the 6 GHz range, and also potential for interference from terrestrial 4 GHz transmitters to the GBMT receiver. The analysis of this potential interference case, where one station is moving along a specified path within a predictable range of speeds, and the other station is static, requires an appropriate methodology, and suitable interference objectives. The ensuing discussion outlines a suggested approach, the "critical contour point" methodology, and suggests that a short-term interference objective can be applied to reflect changes to assess potential exposure intervals that could be caused by the motion of the GBMT system relative to the terrestrial fixed stations it passes.

Working Party 4-9S has determined that there is need for further study by a correspondence group. This correspondence group shall consist of all interested parties in WP 4-9S. They shall conduct their work using the [ITU-R TIES electronic mail system]. The assigned chairman and the work plan for this correspondence group can be found in Annex 1. This correspondence group shall explore the possibility that limitations on specific operating conditions may improve the protection afforded to the fixed service, such as the approach used in ITU-R F.1190 in sharing situations between the digital fixed service and radar systems.

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3 In the United States, for example, the port channels and piers are clearly identifiable on maps available from the U.S. National Oceanographic and Atmospheric Administration (NOAA). The limits of sea lanes, where applicable, are also clearly identified.

4 Commercial cruise ships use most ports on a seasonal basis, and they typically enter and leave a port once or at most twice a week, during the "cruise season" for the area of interest. Other types of vessels such as commercial ships and naval vessels customarily enter and leave port considerably less frequently, often spending months docked between deployments. Commercial vessels such as seismic exploration vessels also make infrequent port visits, since they are usually at sea for long periods of time.

5 When multiple GBMT-equipped vessels operate out of the same port, using the same satellite, available channel frequencies are divided among the individual vessels, to avoid mutual interference at the satellite. Thus, no two vessels in a given port operate on the same frequency at the same time.

## III. METHODOLOGY FOR DETAILED EVALUATION OF POTENTIAL INTERFERENCE TO AND FROM EXISTING USERS

### A. Use of the "Critical Contour Point Methodology" for Analysis of Potential Interference from or to GBMT In-Motion Operations

The "critical contour point" methodology which is proposed for the analysis of the interference potential presented by the relationship of in-motion GBMT-equipped vessels near shore to terrestrial fixed service facilities is based on the following assumptions:

(i) that the operating channel[6] of an in-motion GBMT facility is clearly identified and limited by the specific sea lanes and port channels;

(ii) that within the operating channel of a GBMT facility, for each potentially-affected 6 GHz microwave receiver within the coordination area of the GBMT terminal, there is a *single, identifiable point* (the "critical contour point") within the ship's operating channel that represents the worst-case point for interference exposure from the GBMT transmitter to that microwave receiver;

(iii) that within the operating channel of an in-motion GBMT facility, with regard to each potentially-involved 4 GHz microwave transmitter, there is a *single, identifiable point* (the "critical contour point") that represents the worst-case point for interference exposure from the onshore 4 GHz transmitter to the GBMT receiver; and

(iv) that the critical contour point can be used as the basis for evaluating interference potential for operations in motion in the operating channel between the GBMT earth station and a particular station in the fixed service.

#### 1. Identification of the Operating Channel of an In-Motion GBMT Facility

As noted above, it is essential to the critical contour point methodology to be able to identify the limits of the operating channel of the GBMT facilities aboard in-motion vessels as they approach land, where stationary fixed service and fixed-satellite service receivers may be located. This would not be possible if the courses of such moving platforms were entirely random or variable; however, this is not the case. The vessels which utilize GBMT are large: as such, they can only dock at selected piers in each port, and, more importantly for this discussion, they can only approach such ports within the confines of precisely-identified channels. These channels are identified on maps and charts, and marked in the water by floating buoys or other demarcation devices. These buoys or

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[6] The "operating channel" of the in-motion GBMT facility is the area within the sea lanes and port channels that the ship or vessel equipped with GBMT traverses when it is near the shore, typically when a ship is entering or leaving a port. The "critical contour point" is defined as the point within a GBMT-equipped ship's operating channel that is the "worst case point" for the GBMT transmitter to be located within the composite coordination area of all the possible operating channel locations with respect to potential interference between the GBMT terminal and a terrestrial station.

other markers can be identified by their precise coordinates, and lines can be drawn between their locations on maps to trace the path a large ship must invariably follow when approaching (or departing) a given port. The lines connecting the markers form the outer boundaries of the in-motion operating channel. Accordingly, using known data concerning the pathways large vessels must follow as they approach a given port, it is possible to predict the operating channel of a GBMT facility as the ship moves along those pathways. Figure 1 below depicts the GBMT in-motion operating channel (although the port channel is depicted in Figure 1 as a line, it is a channel).

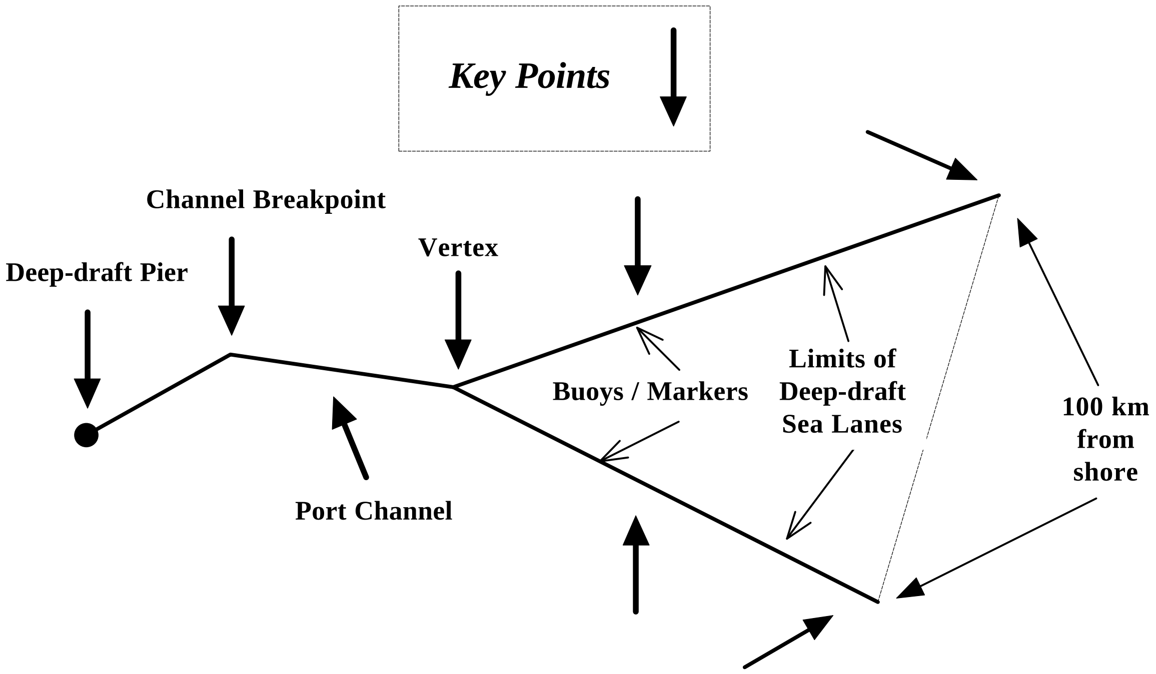


***Figure 1:*** Identification of a GBMT Operating Channel

## 2. Application of the Critical Contour Point Methodology to Analyse Potential for Interference from GBMT Facilities to Terrestrial Fixed Service Stations in the 6 GHz Range

Since, as noted immediately above, it is possible to identify the path of a GBMT facility as the ship or vessel carrying it follows a set course into or out of a given port, it is therefore possible to analyse the relationship of the moving GBMT earth station to a given microwave station onshore as the ship approaches that receiver along the defined operating channel. Employing by way of illustration the case of potential interference from the GBMT transmitter to a terrestrial fixed microwave receiver operating in the 6 GHz band, there are only four position-related variables in the calculation of the "critical contour point," *viz.*: (a) the interfering path distance (as it relates to nominal path loss); (b) the microwave antenna gain/discrimination in the pertinent direction; (c) the GBMT earth station horizon gain/discrimination in the pertinent direction; and (d) any blockage that may exist on the particular interference path. For every discrete point within the in-motion operating channel of the GBMT facility, each of these four factors can be readily determined, as well as the effect of the combination of all four factors. The point within the coordination contour of the in-motion GBMT facility as it proceeds along its defined operating channel which represents the worst-case combination of all four factors is the "critical contour point" with respect to a particular microwave receiver. Figure 2 below illustrates the basic geometry of a potential interference exposure from a GBMT facility in motion to a point-to-point microwave receiver operating in the 6 GHz band (Station A, receiving from Station B).

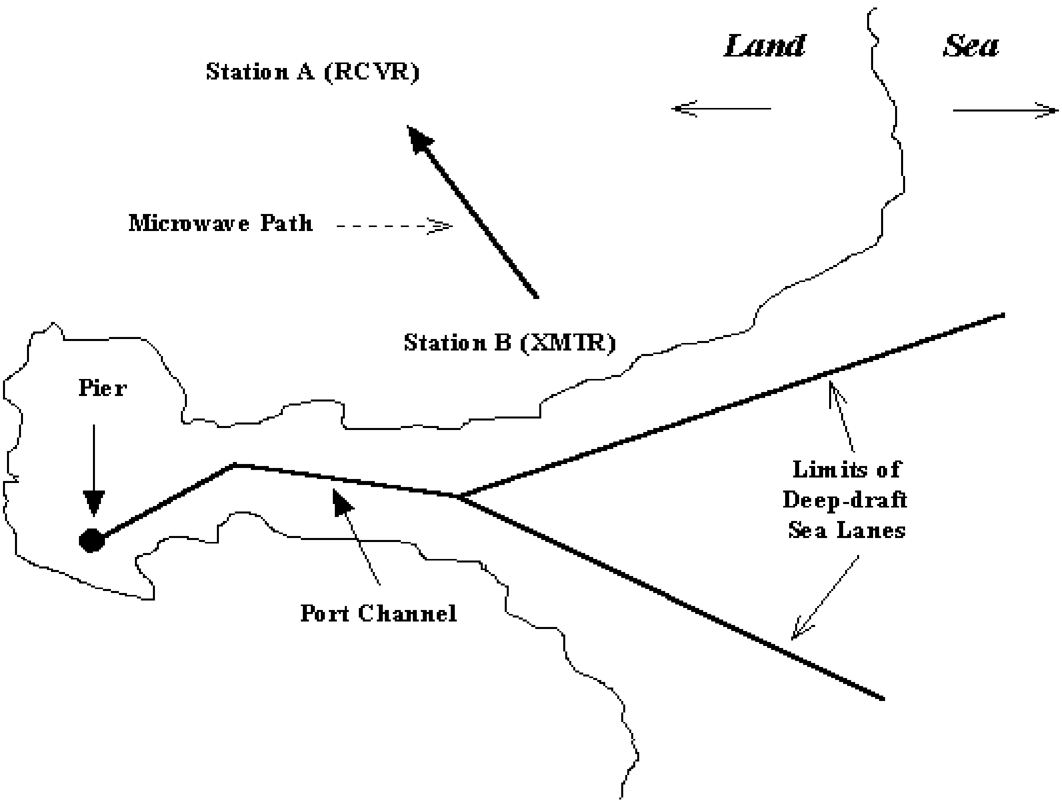


*Figure 2:* Basic Interference Exposure Geometry

The level of the potential interference $(P_r)$ from an earth station to a terrestrial microwave receiver can be expressed in terms of the minimum permissible basic transmission loss:

$$P_r(p) = P_t + G_t(\theta_t) + G_r(\theta_r) - L_b(p) \quad (1)$$

where:

$$L_b(p) = L_D + L_{OH} + L_l$$

$L_b(p)$: basic transmission loss, in dB;

$L_D$: nominal propagation loss over distance $D$ in dB;

$L_{OH}$: additional attenuation due to interference path blockage in dB;

$L_l$: receiver line loss in dB;

$P_r(p)$: interference power for $p$ percent of time, in dBW/4kHz;

$P_t$ : earth station transmit power in dBW/4kHz;

$q_t$: transmit antenna discrimination angle toward the receiver;

$G_t(q_t)$: earth station antenna gain in the direction of receiver in dBi;

$q_r$: receiver antenna discrimination angle towards the transmitter; and

$G_r(q_r)$: receiver antenna gain in the direction of the transmitter in dBi.

To determine whether unacceptable interference would result from the earth station transmitter, the calculated interference power level "$P_r$" for each potentially-affected microwave station is compared to the applicable interference protection objective. Inability to meet the applicable interference protection objective requires that the GBMT station avoid use of the same frequency range(s) used by the potentially affected microwave receiver.

### a. Interfering Path Distance

Greater path distance results in a lower interference level. The implication is that, in general, the worst-case operating location for a GBMT earth station is likely to be closer to a particular microwave receiver, rather than farther away. Accordingly, the "critical contour point" for a given receiver is likely (but not always, as noted below) to be found at or near the edge closest to that receiver of the operating channel of an in-motion GBMT earth station.

### b. Antenna Discrimination

Microwave antenna discrimination is the factor with the greatest variation in the calculation of the critical contour point, since the value of angular discrimination for typical microwave antennas can range from 0 dB (on the main axis, representing maximum gain) to 70 dB or more. Moreover, a given microwave receiver's antenna discrimination angle changes continuously along the edge of the in-motion GBMT-equipped ship's operating channel closest to that microwave receiver. The worst case often occurs when the microwave antenna discrimination is at its minimum, considering the azimuth to different points in the ship's in-motion operating channel -- in some cases, a situation in which the microwave antenna is pointed directly at some point on the in-motion GBMT-equipped ship's operating channel limit.

For many but not all microwave receivers, there is a "natural intersection" of the extension of the microwave antenna's main axis and the limit of the shipboard GBMT earth station's operating channel. At that intersection, the microwave antenna exhibits zero angular discrimination.[7] To either side of that point, increasing angular discrimination usually means less potential interference. "Behind" that point (along the extension of the line joining the microwave transmitter with its receiver, deeper into the area within the GBMT earth station's coordination contour), there is additional path loss. Therefore, one can conclude that the "critical contour" point within the GBMT earth station's coordination contour exists on the edge of the operating channel closest to the microwave receiver (rather than "inside" the channel or at its farther edge). Figure 3 below depicts the "natural intersection" of the extended path of the microwave receiver with the near-side limit of the in-motion GBMT-equipped ship's operating channel.

[7] At this point, the potential interference often exceeds the objective. In such a case, the frequency(ies) used by the fixed service receiver usually cannot be coordinated with the GBMT, and will not be used by the GMBT anywhere in the operating channel.

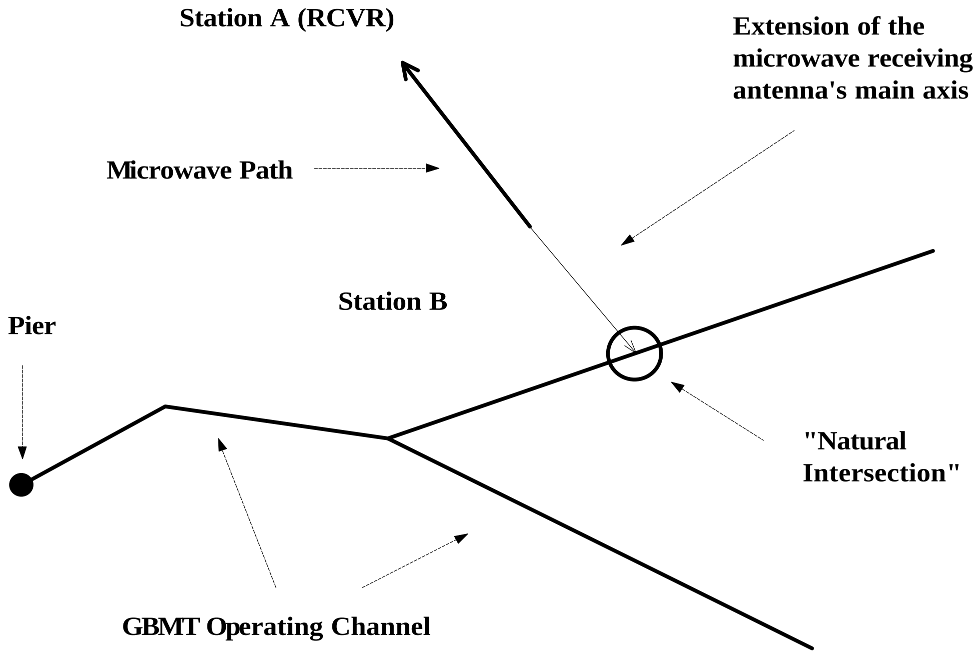


***Figure 3:*** The "Natural Intersection"

At the "natural intersection," the microwave antenna at Station A has zero discrimination, and the path distance to that point appears to be relatively short. To the left or right along the contour, the antenna discrimination increases significantly. The nominal path loss at different points along the operating channel's near edge changes slowly with distance (6 dB per octave), and the differences in antenna discrimination in this case would far outweigh any path-loss differences. In general, it can be concluded that the most likely candidate for the critical contour point is a point at the so-called "natural intersection" if one exists.

## c. GBMT Earth Station Horizon Gain

The GBMT earth station horizon gain varies from a minimum of about -10 dB (for most interference angles) and a maximum of 10-15 dB higher for a limited range of azimuths. This variation can result in the designation of a critical contour point that is different from the simple intersection of the microwave antenna path with the near limit of the in-motion GBMT-equipped ship's operating channel. In Figure 4, for purposes of better illustrating the factor's effect, the diagrammatic model of the earlier illustrations have been adjusted to show the maximum GBMT horizon gain in a southerly direction, and to place a microwave path and its receiving station in that same direction.

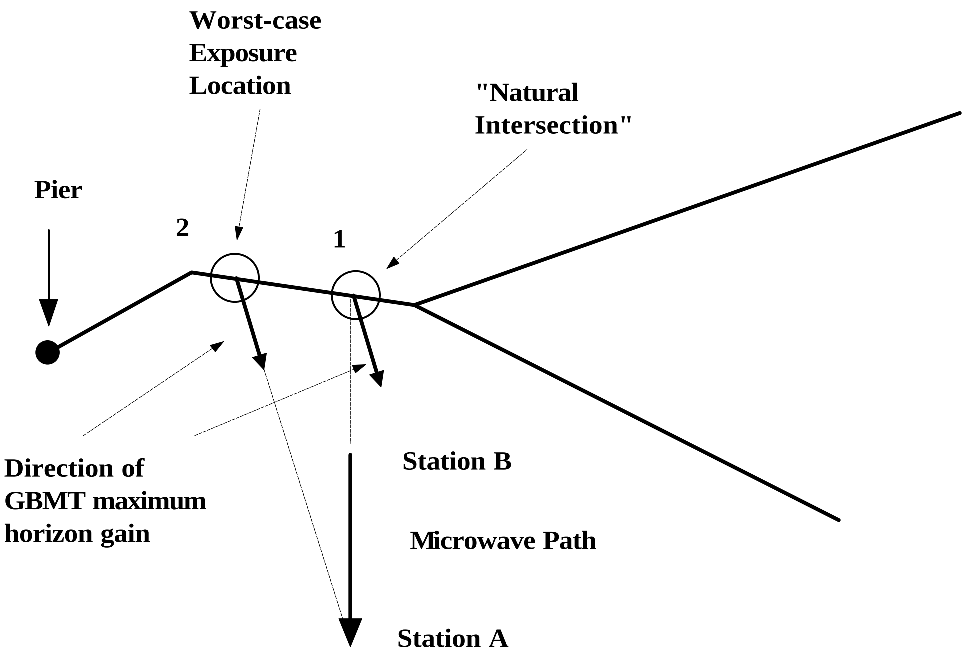


***Figure 4:*** The Effect of GBMT Horizon Gain on the Critical Contour Point

Considering the interference from a GBMT earth station at point 1, the "natural" intersection, assume the GBMT horizon gain is maximum in the direction of the arrow. For that GBMT location, the receiver antenna discrimination at microwave station A is zero. The resulting interference at microwave station A is a combination of the path loss, the GBMT horizon gain (in this case, not at its maximum), and the microwave antenna discrimination. The path loss is about the same at point 2. The GBMT horizon gain, however, is at its maximum (perhaps 10 to 15 dB higher than when at point 1). The microwave antenna discrimination toward point 2 is not zero -- but it may be a value less than the 10 to 15 dB difference in GBMT horizon gain. If that is the case, point 2 -- not the "natural" intersection at point 1 -- is the critical contour point representing the worst-case interference.

### d. Blockage

Terrain blockage effects, characterized by $L_{OH}$ , can also cause the critical contour point to fall at a point different from the intersection of the microwave antenna path with the near limit of the in-motion GBMT-equipped ship's operating channel. If the interference path associated with the "natural intersection" between the microwave receiver and the near limit of the operating channel is blocked, the worst case interference point will fall at the next-worst case location. In Figure 5 (returning to the originally-illustrated interference exposure model) the terrain blockage effect is depicted.

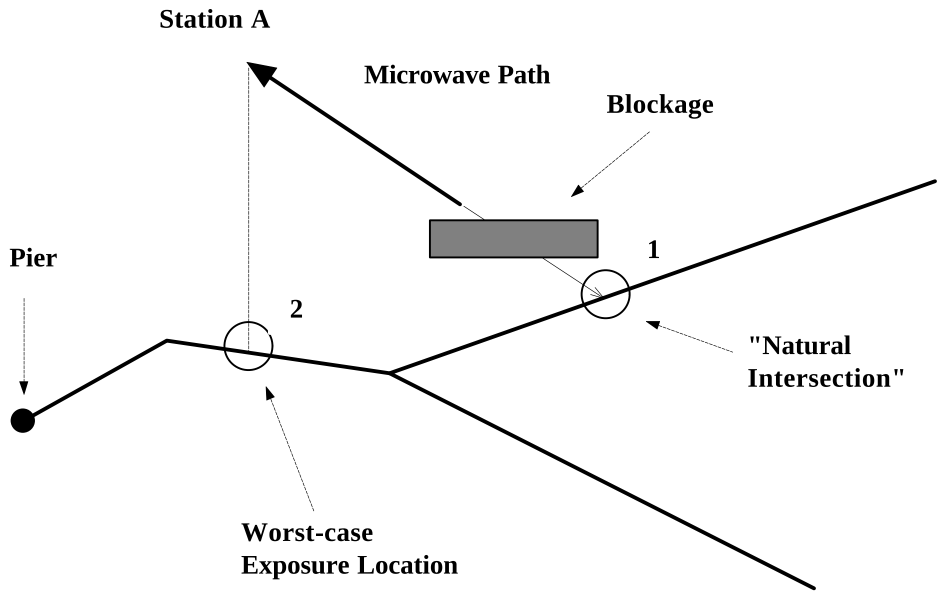


***Figure 5:*** The Effect of Interference Path Blockage on the Critical Contour Point

In this case, the interference path associated with the "natural" intersection at point 1 is blocked and exhibits high transmission loss. The critical contour point may actually be at point 2, because that interference path is not blocked and the combined value of path loss and microwave antenna discrimination may result in lower transmission loss, resulting in a higher level of interference at point 2 than at the point of intersection of the "natural" path subject to the blockage with the near limit of the GBMT-equipped ship's in-motion operating channel. (The GBMT horizon gain was assumed to be the same for both interference paths.)

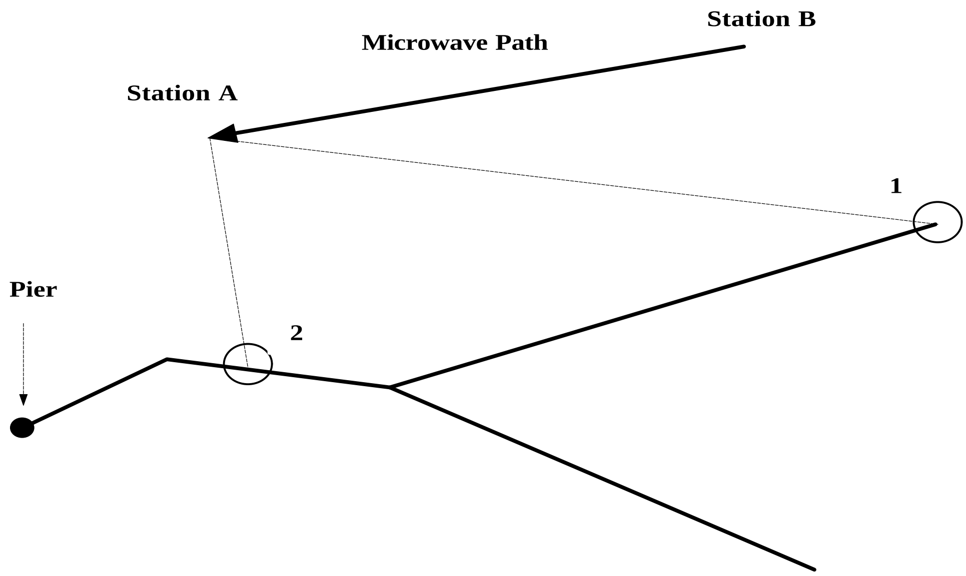


*Figure 6:* Critical Contour Point for a Microwave Path with No "Natural Intersection"

## e. Non-Intersecting Microwave Paths

The case in which the extended path line of a microwave path does not at all intersect the limit of the GBMT-equipped ship's in-motion operating channel is depicted in Figure 6 above.

In this case, the analysis principles and techniques remain the same as described earlier, even though a "natural" critical contour point cannot be identified by the intersection of the microwave path and the ship's operating channel limit, since no such intersection exists. In these cases, the determination of the critical contour point is primarily a factor of microwave antenna discrimination and interference path loss at different points along the operating channel limit. The critical contour point for the receiver at Station A may be at point 1, because the antenna discrimination may be at its minimum at that respective angle. However, a check must be made that the point might not otherwise exist at point 2 (or elsewhere along the GBMT in-motion operating channel limit), where the microwave antenna discrimination is greater than zero, but the path loss might be lower by a more significant difference, thus making some point other than point 1 the worst-case point for GBMT interference.

For these types of situations, just as in the others discussed earlier, the critical contour point along the continuum of the near edge of the operating channel can be determined by calculating the simultaneous worst-case combination of path loss, microwave antenna discrimination, GBMT horizon gain, and terrain blockage effects for each candidate point. If the worst-case GBMT interference location (or area) is determined and demonstrated to meet an applicable interference objective, then GBMT operation throughout the in-motion operating channel may be deemed not to cause unacceptable interference.

### 3. Application of the Critical Contour Point Methodology to Analyse Potential for Interference to In-Motion GBMT Facilities from Terrestrial Fixed Service Stations in the 4 GHz Range

In the case of potential interference to an in-motion GBMT receiver from a terrestrial 4 GHz microwave transmitter, the same critical contour point analysis applies, except it takes into account the GBMT system's receive characteristics, and the transmitting characteristics of the fixed station. The critical contour point along the continuum of the near edge of the ship's operating channel can be determined by calculating the worst-case simultaneous combination of path loss, GBMT antenna discrimination, microwave transmitter gain, and basic transmission loss for each candidate point. If the worst-case location within the microwave transmitter's coordination contour for interference to the GBMT earth station from the microwave transmitter is determined and demonstrated to meet the applicable interference objective, once agreed and with appropriate regulatory status, then GBMT operation throughout the in-motion operating channel will be possible without unacceptable interference from that microwave transmitter.

### B. Satellite Intra- and Inter-System Interference Issues

Two other potential interference cases (satellite intra- and inter-system interference) theoretically arise when an in-motion GBMT earth station approaches the location of a fixed-satellite earth station. These potential interference cases will not present difficulties, however, provided that the GBMT earth station, like all other fixed-satellite service earth stations, complies with the antenna performance operating parameters established in ITU and INTELSAT specifications as set forth by ITU-R S.524-5, S.580-5, S.731, S.732 and IESS 601, which are specifically designed to avoid unacceptable satellite intra- and inter-system interference. It is intended that GBMT-equipped vessels comply with all relevant ITU-R recommendations.

## IV. CONSIDERATIONS FOR THE DEVELOPMENT OF APPROPRIATE INTERFERENCE PROTECTION OBJECTIVES FOR GBMT SYSTEMS USING A SINGLE-SHIP ANALYSIS

### A. Long-Term and Short-Term Objectives

A review of methodologies contained in existing ITU-R Recommendations applicable to protection of fixed service microwave receivers against unacceptable interference from an uplink satellite earth station suggests that it would be appropriate to develop both a long-term interference protection objective and a short-term interference protection objective to be applied to GBMT operations. The parameters and methodologies required to develop such objectives are discussed in ITU-R Recommendations IS.847 (coordination area) and SF.1006 (interference potential) and Appendix S7 of the Radio Regulations. A long-term objective would be a level of potential interference that might not be exceeded more than 20 percent of the time, and a related short-term objective could be specified for a variety of exposure levels and durations.

As noted above, stationary GBMT operations in port could be coordinated as a fixed-satellite service earth station. In-motion GBMT operations, however, require a different approach since the constant motion of a GBMT-equipped vessel while in the operating channel affects the fixed receiver over a portion of its operating track. Because the track of a large vessel in its waterway is severely restricted both as to changes in speed and direction, it is possible to perform an approximate analysis to develop a perspective on the problem. Indeed, because the operating channel is not a line, but rather is an area of potential operations, transmission from any discrete point in the operating channel is only a statistical possibility. Because the motion of the GBMT-equipped vessel relative to the static terrestrial stations it affects (or is affected by) entails variable exposure levels, when a co-channel frequency can be satisfactorily coordinated, it should be possible to ensure satisfaction of both "short-term" and "long-term" interference protection objectives by limiting the exposure.

## B. Development of Interference Objectives for In-motion GBMT Operation

One of the key issues in determining the applicable interference objective(s) is the percent of time that a receiver is exposed to a given level of potential interference. The following is a preliminary assessment based on the discrimination of the fixed service antenna discrimination and an assumption that the worst case interference exposure is at a critical point that corresponds to a natural intersection of the antenna maximum gain and the track of the vessel. If the interference potential of a fixed earth station at this point would meet both the long and short-term interference criteria, the potential interference would meet the criteria for acceptance. If the interference potential of such a fixed operation would meet only the long-term criteria, there is a need for further consideration.

Consider as an example a case where the long-term criteria for fixed operation is exactly met at the critical contour point. That is, the basic transmission loss not exceeded for 20 percent of the time along with the maximum gain of the FS receiving antenna will just satisfy the permissible level of interference for 20 percent of the time. However, such a view does not account for the motion of the ship, which will reduce the percent of time that the interference is at this level. A typical fixed service receiving antenna in this band may be found from the characteristics in Appendix S7(28) or Recommendation ITU-R IS.847 to have a 3 dB beam width of about 1 degree. The total time in a year that the operations place the earth station within this beamwidth may be calculated as $T_s$ for this simple intersection as follows:

$$T_s = (dN / v)\, 2 \tan (\varphi / 2) \qquad (2)$$

where:

*d*: the distance (km) between the microwave receiver and the GBMT antenna;

*N*: the number of passes[8] per year on that particular path made by the GBMT-equipped vessel;

*v*: the average speed (km/h) of the vessel; and

$\varphi$: the 3 dB beamwidth (degrees) of the fixed service receiving antenna.

The time that it takes for the GBMT-equipped vessel to traverse the main beam of the receiving antenna increases proportionally with the distance of the receiver from the critical point. Assuming a value of 100 km for this distance and using a value of N of 200 passes in a year at an average speed of 16 km/hour, the ship would be in the main beam for about 20 hours or 0.2 percent of a year. If this were the only time that the interference was close to the value permissible at the

[8] For purposes herein, a "pass" is defined as the event of a GBMT-equipped vessel travelling either into or out of a port, and a "trip" as two passes.

20 percent level, one would conclude that the use of the long term (20 percent) permissible interference would be too restrictive. Although the level of interference could exceed this value when the vessel is outside the 3-dB beam width, it is expected that the occurrences of such levels would be minimized because of the additional antenna discrimination provided by the FS antenna and possibly the earth station antenna.

While further study is needed, it is postulated that an interference criterion significantly below the level used for a long-term interference criterion would be appropriate for GBMT operations. Several studies of the interference potential posed by these operations are currently underway in the United States.

## IV. CONCLUSION

GBMT-equipped vessels could operate compatibly in the 3700-4200 and 5925-6425 MHz bands with existing fixed service and fixed-satellite service users under some conditions. When in open sea, GBMT operations generally do not affect, and are not affected by, terrestrial stations, provided the GBMT operations are in compliance with standards applicable to all fixed-satellite service earth stations. When stationary in port, GBMT-equipped vessels could be coordinated with fixed service stations utilizing certain procedures and applying agreed standards. For in-motion GBMT operations close to shore, a suitable interference analysis method, such as the single-ship critical contour point method (explained above), shows promise for the determination of the interference potential between these earth stations and fixed service stations. This analysis needs to be expanded for multiple-ship applications. The development of appropriate objectives for use with this methodology requires further study.

ANNEX 1

**Correspondence group Work Plan**

Working Party 4-9S has determined that there is need for further study by a correspondence group on the following three topics.

1) Determination of the coordination requirements for earth stations on vessels including but not limited to:

- Technical characteristics of earth stations on vessels;
- Operating constraints that may be used to mitigate or eliminate the need for coordination;
- In-motion aspects that may be useful in determining the potential for interference;
- Propagation effects that may be important in determining coordination area;
- Automatic controls for exclusionary zones.

2) Demonstration of the proposed coordination method between an earth station on a vessel and stations in the Fixed Service including but not limited to:

- Example coordination and calculations of the potential interference;
- Validation of coordination results through a simulation.

3) Consider inputs resulting from Questions ITU-R [Doc. 4-9S/TEMP/21]/4 and [Doc. 4-9S/TEMP/23]/9:

- Conditions for sharing with stations in the fixed-satellite service;
- Conditions for sharing with stations in the fixed service.

These studies must be completed in time for the results to be reported at WP 4-9S's next meeting, 28 September - 3 October 1998.
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